CHAPTER SEVEN

PUMPS

Engine power is used through reduction gearing to work feed water, and often oil and fuel pumps, to operate the flash-steam plant. The correct amount of each fluid supplied is most important. Possible means for metering will be considered under each system.

The boiler feed pump

The duty of any boiler feed pump is merely to balance evaporation. In conventional boiler feeding, the output of the water pump is usually arranged to provide a surplus of water. The 'balance' is controlled by regulation of a valve within the delivery pipe, which spills some of the water, and returns it to the feed water tank, or in the case of most marine installations, overboard. Such a system works reasonably well if the boiler pressure does not fluctuate and if the loss of steam through safety valve and auxiliaries is moderate. The operator of such boiler plant, however, has a reserve of water available by use of the emergency hand pump, he is also aware of boiler contents by observation of the water gauge.

Operation of a flash boiler does not always permit the opening and closing of a by-pass valve to spill water. Spillage of water through this valve will only remain constant for a regular boiler, or to be more correct, steam generator pressure. A rise in pressure provides more resistance at the check valve resulting in increased spillage; the water taking the path of least resistance. It may equally be understood that a drop in pressure permits more water to enter the boiler tubing.

Insufficient water passed to the coil of boiler tube will not generate the quantity of steam required, but may superheat the steam beyond the temperature at which the engine can safely operate. Delivering water to the boiler in excess of heat applied promotes low steam pressure without superheating; wet steam is generally of little use. In fact, flash plants having no specific water or temperature controls tend to be unstable, either the steam is too wet or too hot!

Mention should be made here of the pressure relief valve used by Prof. D. H. Chaddock on one of his experimental steam turbine plants. It consisted of a spring-loaded ball valve in the pump feed line loaded
ca 35 bar to blow at 500 *psi*. Using turbine nozzles of calculated proportion the arrangement provided a considerable measure of control. It was found necessary to fit a check valve between the relief valve and the boiler. Without it all the water in the tubing tended to be lost when the valve operated, rather than merely surplus feed water being eliminated.

J. Bamford has used a similar valve on his latest flash steamer, reporting that it prevented the typical slowing towards the end of the run. This is interesting because in theory the arrangement should not work with a reciprocating engine plant.

(In a turbine plant the steam consumption is governed by the nozzles and is quite independent of the rotor speed and thus the pump speed, which is not the same as when a reciprocating engine is used.)

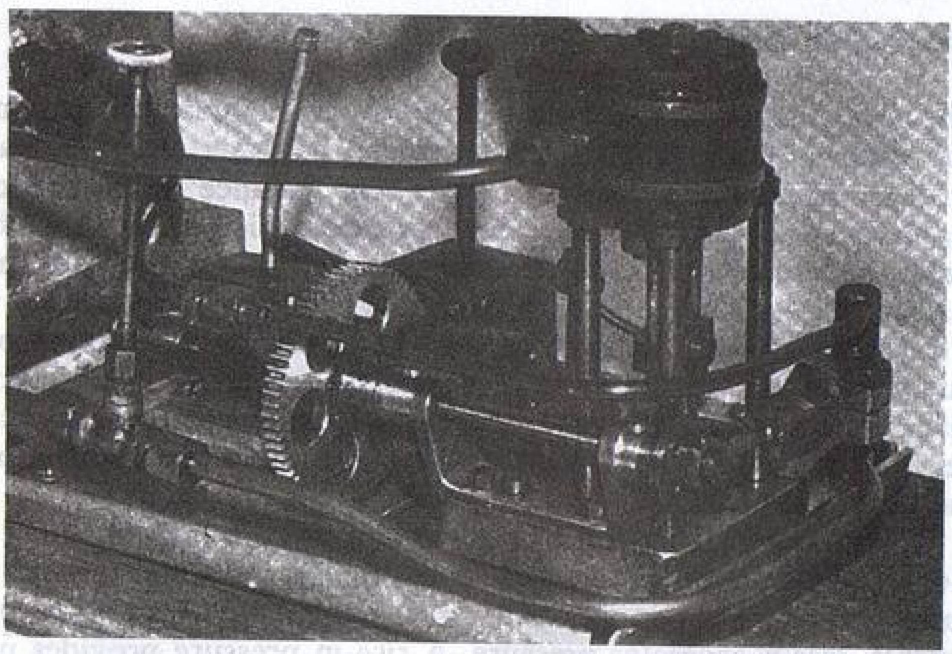


Plate 21 H. W. Saunder's water feed control (left). The engine is built to E. T. Westbury's 'Trojan' design, with pumps and gearing added

Another interesting method of control is used by H. W. Saunders (St. Albans) in a moderate performance plant (*Plate 21*). In this instance, the inlet to the feed pump is deliberately restricted by means of a ball valve, the lift of which is limited by a simple screw control.

This device works well; once set, speed can be adjusted by the heat supplied, and the plant will continue running as long as the fuel lasts. As far as is known this arrangement has not been adopted by hydroplane exponents, but it might solve many problems if it would operate at the high pump speeds required.

An ideal water pump should be capable of exact metering. Indeed, some past flash-steam plants applied to model work incorporated levers and linkage to vary the travel of the ram, even while working. Simplicity and reduction of weight has always to be considered in mechanical systems, alternative means can be applied to vary output from the pump. As the bore of the pump is constant, variation of the movement to the ram is the only method available to vary output. To vary the stroke of the ram, a connecting rod with a screwed-in crankpin is applied to tappings of differing radii within a crank disc (*Fig. 7.1*).

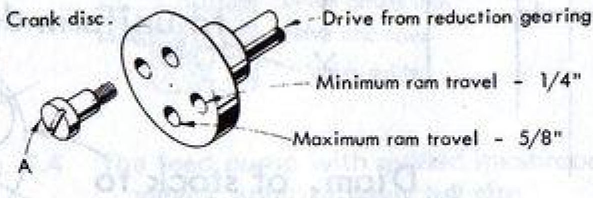


Fig. 7.1 A pump-driving crank illustrated at about half-size. The crankpin, indicated by A, is screwed in at various radii

It is most important that the ram travels the length of the barrel, any dead space between the end of the ram and the delivery valve could trap air, forming a cushion and reducing effective working. It follows that variations of the stroke by alteration of the driving crankpin, must also provide for bodily moving the pump and flexing of pipework to avoid

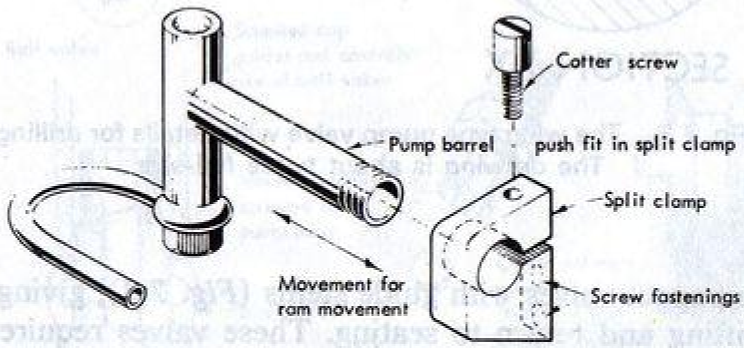


Fig. 7.2 The pump support clamp is shown at approximately half-size. The curved pipework is left soft to permit flexibility of banjo union swivels

dead space within the pump barrel. The mounting to provide for alteration of pump position may be provided by a simple split clamp, as shown in *Fig. 7.2.*

Other important design features should provide for accurate fitting of the ram, either with ram packing, 'O' rings or a screwed packed gland, to resist leakage and operate with minimum friction. Perfect sealing of both suction and delivery valves is without doubt of utmost importance. The valves used in past flash-steam pumps have taken several forms. The wing type (*Fig. 7.3*), which, with some variations

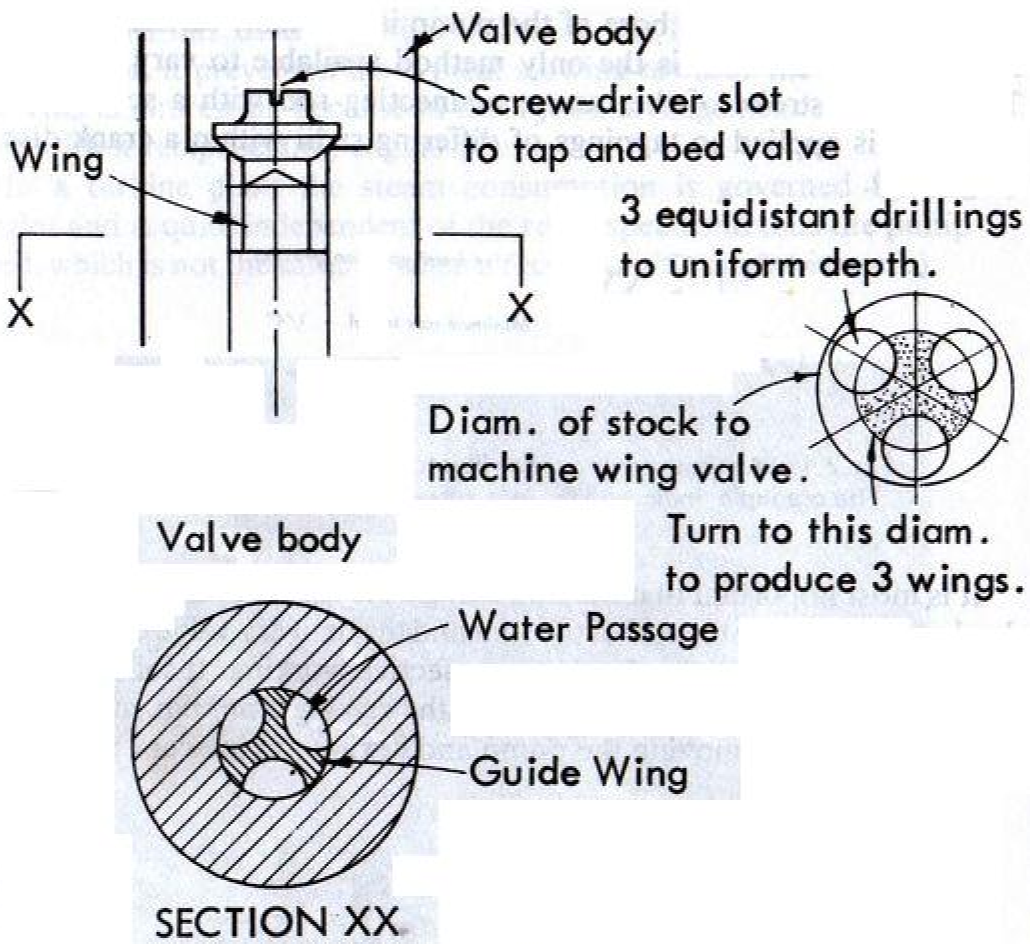


Fig. 7.3 The wing type pump valve with details for drilling. The drawing is about twice full-size

turns into poppet valves with guide stems (*Fig. 7.4*); giving accurate seating, lifting and return to seating. These valves require machine operations and turning of small diameter stock to accurate limits if they are to be trouble free. It is thus that the ball-type valve is more generally employed within model and small pumping mechanisms. A large selection of both stainless steel and phospher-bronze balls are readily obtainable.

Pumps in racing flash-steam plants work rather fast even though geared down. Some means of assisting rapid and complete closure of the valves should be incorporated in the design of the pump.

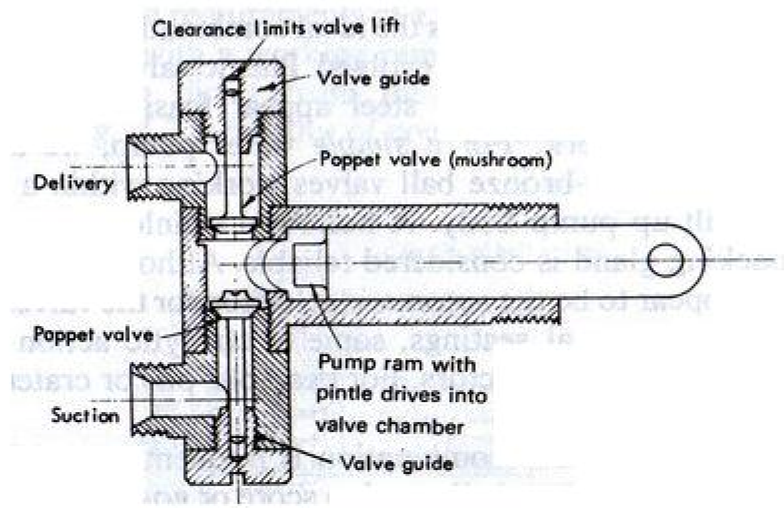


Fig. 7.4 The feed pump with guided mushroom (poppet) valves, approximately full size

With ball valves, the lift or rise of each valve must be controlled. Some means should be provided to prevent side movement, without restriction of the waterway. This may be achieved by fitting a cap over each valve or providing a cage around the ball, as in *Fig. 7.5*.

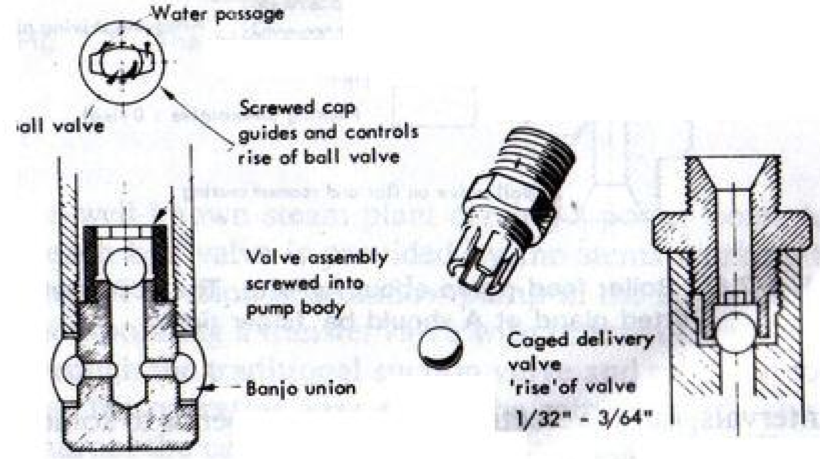


Fig. 7.5 Guided ball valves

The selection of materials used in the construction of the water pump is important. Some dissimilar metals or alloys united through water promote electrolytic action, often resulting in pitting or wasting of the base material. Several constructors have used, and still continue to use, aluminium alloy for water pumps in order to reduce weight. More than a few headaches have resulted when the pump failed due to oxide fouling the valves. Perhaps the ideal combination of materials for pump construction has yet to be evolved. Plastic valves, non-corroding aluminium alloy and stainless steel appear feasible, working into stainless steel pipework. For a *simple* water pump, we advise the adoption of phospher-bronze ball valves working within a gunmetal casting or built-up pump body. A hollowed stainless steel ram with screwed packing gland is considered reliable. Although stainless steel balls would appear to be the automatic selection for the valves working upon brass or gunmetal seatings, some electrolytic action has been experienced by past constructors. For example, pits or craters form in the steel balls.

Despite this, the above combination is frequently used for racing plants, as phospher-bronze balls tend to score or go out of shape under extreme conditions. The seats and ball valves may be inspected at

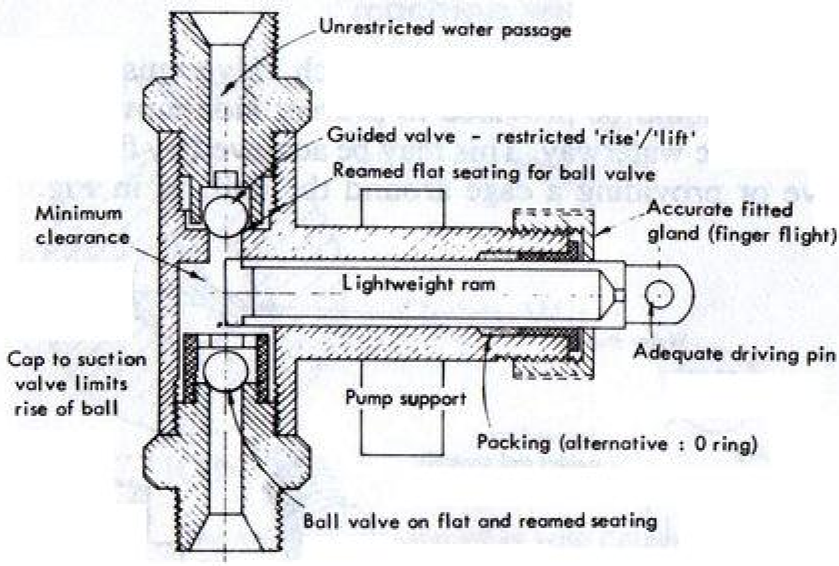


Fig. 7.6 Boiler feed pump about full-size. The accurately fitted gland at A should be 'finger tight'

regular intervals, but the electrolytic trouble depends to some extent on the purity of the water available.

The best method of seating ball valves is, first, to solder a ball of the same diameter on a piece of tube of slightly smaller size. This is rotated in a drill chuck and the valve seat burnished. No abrasive is required and less than a minute of this treatment will do the trick.

The most perfect feed pump can fail if microscopic debris passes through with the water. A suitable filter must be incorporated, either in the pick-up system for marine installations or within the feed water-tank: details of filters are mentioned elsewhere.

The basic design requirements of a water pump are indicated in *Fig. 7.6*. For a pump with a working ram speed of say 4,000 strokes per minute, operating direct from the engine crankshaft the design indicated in *Fig. 7.7* is worthy of consideration. The design has been

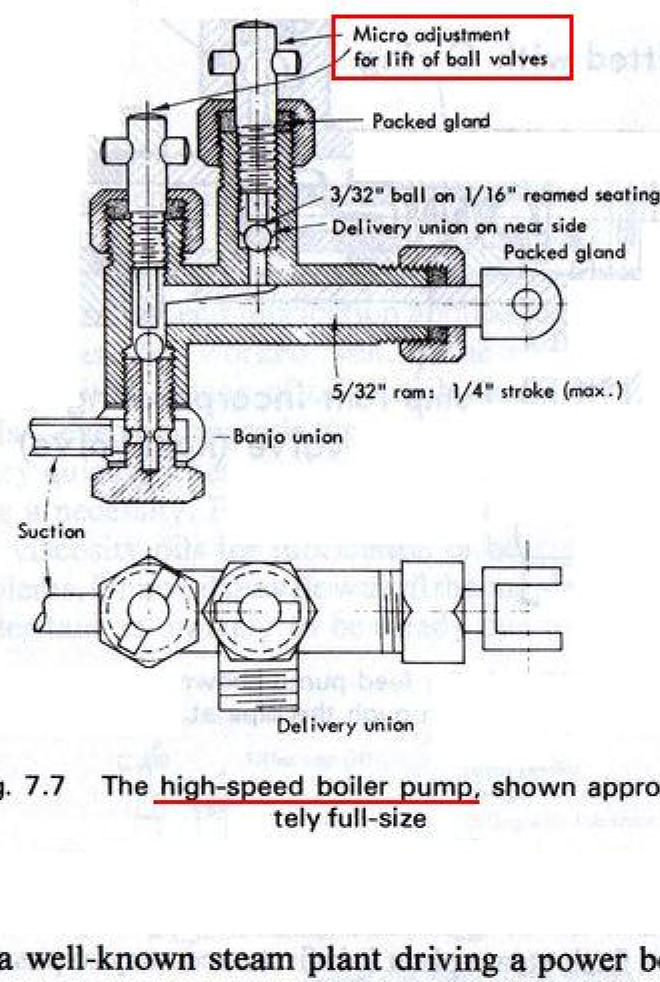


Fig. 7.7 The high-speed boiler pump, shown approximately full-size

applied to a well-known steam plant driving a power boat. Accurate control of each ball valve is provided by the stems working through packed glands. Provision of a uniflow pump in the larger size may be made by incorporating a transfer valve with the ram (*Fig. 7.8*). Water is drawn through the traditional suction valve and passes through the ram valve as the operating gear drives the ram forward. The reverse travel discharges the contents of the barrel through the delivery valve while drawing in another charge of water. This form of pump relies on a well-fitted ram, this may now be done with the well-known 'O' ring.

Past constructors had to rely on graphited packing or leather cup-washers. The fitting of the gland to this pump, and indeed, all pumps, must be accurately carried out; the inclusion of a pressure sleeve within the gland is advised. The assembly should only be tightened

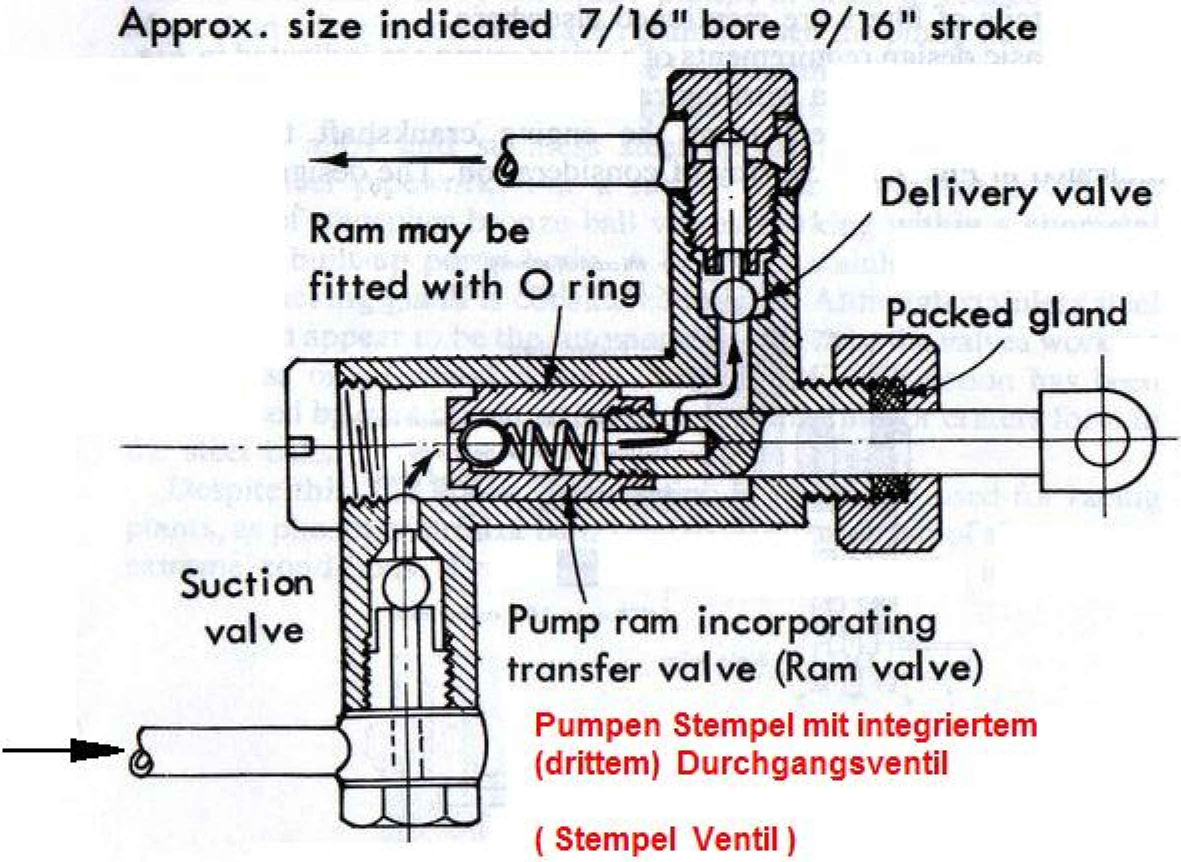
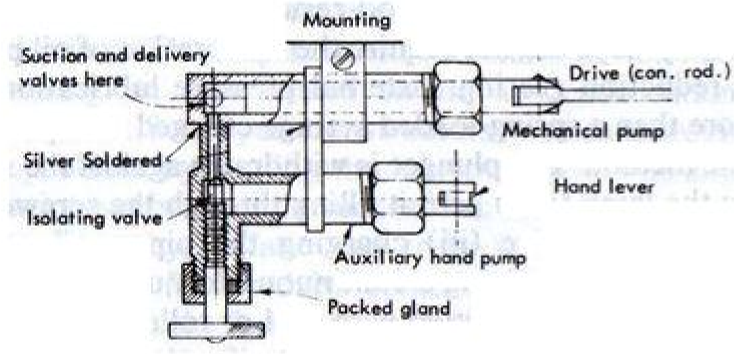


Fig. 7.8 Uniflow boiler feed pump shown full-size. Water enters the pump through the pipe at the bottom

sufficiently to compress the packing and prevent leakage, a knurled edge to the gland nut is often sufficient for finger operation.

To start up a flash-steam plant it is first necessary to pass pass some water to the boiler to generate steam and turn the engine. An auxiliary hand-operated pump forms part of the steam plant. To reduce weight and complications, some racing hydroplanes incorporated a combination pump, two barrels and rams working into a common chamber of suction and delivery valves. Naturally, only one ram can operate at one time. After the initial generation of steam and revolving of the engine, the barrel and ram of the auxiliary pump has to be isolated from the valves. *Fig. 7.9* indicates a typical arrangement.



ig. 7.9 Feed pump with starting up auxiliary pump, shown half-size

Oil pumps

Lubrication of steam engines applied to power boats often relies on the simple gravitation of oil from a small header tank to oil cups on bearings and other parts. This is quite satisfactory for many bearings. A gravity system of big-end lubrication applied to high-speed, double-acting engines has also worked well. Some applications, however, require more positive means of oil distribution.

Motor-oils—even multi-grade types—tend to run through the smallest pipes very quickly when working temperature is reached. Delicate restriction is a necessity. For this reason, model steam engines often have higher viscosity oils for lubrication of bearings. These oils also present problems, for no oil may flow until the engine warms up! Oil feed from a header tank is unlikely to be steady due to these variations in

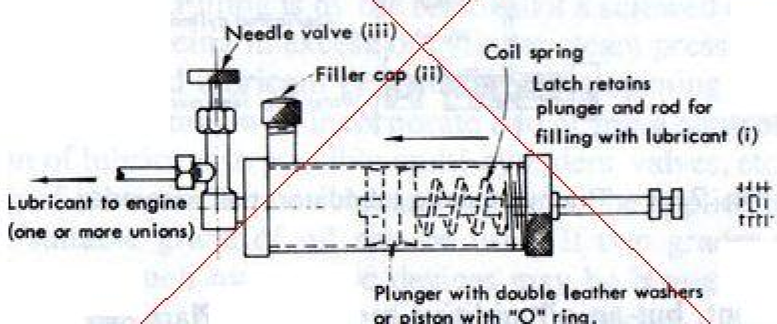


Fig. 7.10 Simple pressure lubrication for the bearings and external parts

viscosity relating to temperature. Some bearings are starved, while others tend to receive more than their fair share—friction in small-bore pipes plays funny tricks.